
Smallpox Eradication

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This paper concerns a truly epochal event. I wrote the word "epochal" for this introduction and then thought about it. Since it means "opening a new era in human history," this overworked word is no exaggeration and it is peculiarly appropriate to the topic. It is also appropriate that WHO has just recently announced the eradication of smallpox. From what I have read, the achievement resulted not from possession of a magical new weapon such as a new vaccine, but from slight modifications in the use of a very old one, in fact, the oldest of all vaccines. It was based, furthermore, on some very old epidemiologic techniques, including intensive surveillance and reporting of the disease. It was the way in which forces were marshaled on a global scale to apply focal immunization around every local outbreak that was new and that gave the victory. To tell this story, we are fortunate to have Dr. D. A. Henderson, who spearheaded this epochal accomplishment for the WHO. He is now dean of Johns Hopkins School of Hygiene and Public Health.—PHILIP SARTWELL, MD

IN A CEREMONY IN NAIROBI, KENYA, on October 26, 1979, the Director-General of the World Health Organization, announced (1,2):

The last of the International Commissions for the Certification of Smallpox Eradication today confirmed the

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eradication of smallpox in the Horn of Africa, the last stronghold of this disease. A Global Commission will meet in December to compile documentary evidence for final review by the World Health Assembly. However, I am confident in stating that as of today, smallpox has been eradicated throughout the world. October 26 shall henceforth be designated as "Smallpox Zero" day—a day of remembrance and reaffirmation of the achievement possible when peoples everywhere band together, without regard to politics or national glory, in pursuit of a common goal.

This day marked the second anniversary of the last naturally occurring case of smallpox, a case which had occurred just 10 years, 9 months, and 26 days after the World Health Organization had embarked on its projected 10-year campaign.

For myself and for so many of us who, for more than a decade, had shared the vicissitudes of bureaucracy and the field, the skepticism of critics, and, occasionally, the doubt of personal conviction in anticipation of this moment, it was gratifying, disappointing, and sad. Gratifying in at last reaching "Target Zero"—for us, the long sought Holy Grail; disappointing in the realization that the joy, as it often is, was more in the journey than in reaching the destination; and sad in the realization that a program had terminated which had provided a unique common bond, transcending nationality, race, and religion, uniting as extraordinary and as dedicated a group of people as any with whom I have ever worked.

This achievement, however, should be viewed in perspective.

Historians of science have amply demonstrated that events such as this are complex phenomena which do not occur in a vacuum but, rather, of necessity build on the knowledge of the past and the currents of the present. We need to recall the past, since it was both definitive and directing. As to the future, the implicit lesson, as I shall elaborate, is not that we should seek to define what we can eradicate next, but rather, that we appreciate the need for epidemiology in disease control programs when the tools are at hand and the goals are clear.

Eradication Initiatives

Over past decades, many have speculated about the global eradication of a disease, among them Edward Jenner (3). However, definitive plans to actually undertake such a venture date back to William Gorgas, who in 1908 boldly argued that yellow fever could be eliminated with relative ease by temporary anti-*aegypti* campaigns in key endemic centers (4). In 1915, the Rockefeller Foundation established

the Yellow Fever Commission to collaborate with governments in the infected countries to eradicate yellow fever from the world (5). Eradication in the Americas was thought to require 5 to 10 years; Africa would follow later. By the late 1920s, victory in the Americas appeared to be in sight—but in 1932, a jungle reservoir of the virus was discovered. By then, Dr. Fred L. Soper, an aggressive proponent of eradication, had replaced Gorgas as head of the Commission. Abruptly, he shifted the strategy from eradication of a species of mosquito, *Aedes aegypti*, the urban vector of yellow fever. The results were encouraging, but the logistics were formidable and progress was slow. In the meantime, *Anopheles gambiae*, imported from Africa into northeastern Brazil about 1930, had spread along the coast, resulting in disastrous malaria epidemics. The Rockefeller Foundation joined with the Government of Brazil in a new effort to eradicate this vector but, as Soper recalled, with the stern injunction to its

representatives not to commit it to another eradication program. This time, success was achieved.

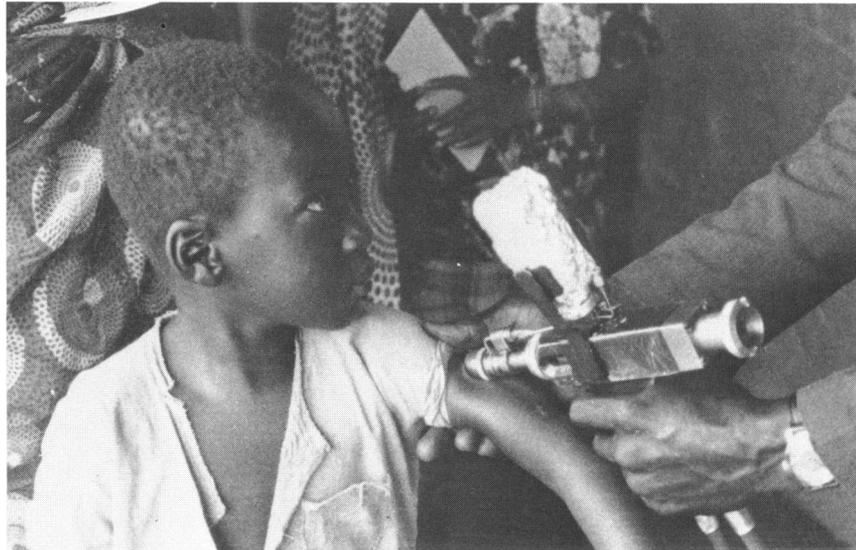
After World War II, Soper assumed the helm of the Pan American Sanitary Bureau, and, in 1947, a resolution was passed by its Directing Council, calling on the Bureau to work with the countries of the Americas in the prevention of urban yellow fever through the eradication of *A. aegypti* (6). It was the first resolution that delegated responsibility to an official international health agency to coordinate activities in a number of countries in the solution, through eradication, of a regional health problem. It was not to be the last.

Only 3 years later, in 1950, the eradication horizon in the Americas was broadened to encompass malaria, yaws, and smallpox (6). And 5 years later, in 1955, the World Health Assembly endorsed “a program having as its objective the worldwide eradication of malaria” (7). The term “eradication” had begun to assume a mystical life of its own, not unlike the term “pri-

mary health care" today. In 1959, the Assembly endorsed also, as an objective, the global eradication of smallpox. Enthusiasts began to speculate about the possibility of eradicating poliomyelitis, tuberculosis, and even poverty and hunger. With the proliferation of nuclear weapons, speculation about the eradication of another species—man—seemed to some rather more probable.

International assemblies are renowned for their rhetoric and for their resolutions. Translating commitments into practice, however, has proved more difficult. By the mid-1960s, it was apparent to even the most optimistic that effective malaria control, let alone eradication, was beyond the reach of existing technology. *A. aegypti* eradication had encountered other obstacles. Smallpox eradication had met with only limited success. It was clear that elimination of these as well as other diseases was possible under certain environmental conditions, where there was political stability, economic development, a developed health system, and adequate resources. The frequent argument that successful elimination of a microbe in one area implied the possibility of a parallel success in all other areas seems today a bit naive. Dr. Walsh McDermott, as quoted by Dubos (8), summed it up in his characteristically pungent style: "There are no rattlesnakes in the streets in Houston but their elimination from big cities does not mean eradication from the state of Texas."

By the mid to late 1960s, the eradicationist philosophy was increasingly being regarded as wishful ideology, and in 1967, ironically the first year of the intensified global Smallpox Eradication Program, Rene Dubos in his book, "Man Adapting," bluntly addressed this issue (8):



Even if genuine eradication of a pathogen or vector on a worldwide scale were theoretically and practically possible, the enormous effort required for reaching the goal would probably make the attempt economically and humanly unwise. . . . Social considerations, in fact, make it probably useless to discuss the theoretical flaws and technical difficulties of eradication programs, because more earthy factors will certainly bring them soon to a gentle and silent death. Certain unpleasant but universal human traits will put impassable stumbling blocks on the road to eradication. For example, it is easy to write laws for compulsory vaccination against smallpox, but in most parts of the world people would much rather buy the vaccination certificate than take the vaccine; and they always find physicians willing to satisfy their request for a small fee.

Intensified Smallpox Initiative

The decision by the 1966 World Health Assembly to embark on an intensified 10-year effort to eradicate smallpox was made as the eradicationist era was drawing to a close. The views of Dubos eloquently and, I believe, accurately reflected those of most of the scientific community. Not surprisingly, the decision of the World Health Assembly was less than enthusiastically endorsed. Few expected more than better control of smallpox. Those of us who were then young and naive with respect to the problems of mounting programs that

had to be coordinated transnationally in many of the least-developed parts of the world ascribed the negative views to the lack of technical understanding by the critics. Today, older and wiser, I well appreciate the reservations expressed. Despite the simplicity of technology and the uniquely favorable epidemiologic characteristics of smallpox, I can state that the resources, both human and financial, were repeatedly stretched to and often beyond conceivable limits. More than this, we were impressed by the occurrence again and again of timely and extraordinarily fortuitous political and natural events which permitted realization of the goal. The goal was achieved, but by only the narrowest of margins.

The smallpox eradication initiative clearly was the historical grandchild of Gorgas's yellow fever eradication program of the 1920s and perhaps the last such initiative of this century. I now see no other candidate disease for global eradication—no other disease with the appropriate combination of severity and suitable epidemiologic characteristics and for which we have appropriate and affordable technology to permit eradication. It is important to point out that the strategy neces-

sary to achieve disease eradication and the resources required are different from those required for disease control. More than this, as we have seen with malaria, distortions created by the eradication program have preempted the development of effective control programs. I would conclude, therefore, that the logical next step is not to seek yet another disease for eradication but to eradicate for now the word "eradication."

Surveillance Strategy

Yet, smallpox eradication did succeed—despite the explicitly stated reservations of Dubos and the scientific community and the openly expressed doubts of so many who had extensive practical experience in the execution of public health programs. Ultimately, a single element, a single addition to the strategy of the program was responsible—that change was the incorporation of the principle of surveillance (9).

When smallpox eradication programs had begun in 1959, the strategy had called for mass vaccination campaigns designed to reach 80 percent of the population. Employing this approach, several countries did become free of the disease but in most, the strategy failed. New Delhi, India, which reported having vaccinated 120 percent [sic] of its population, experienced its largest epidemic in a decade. Something was wrong. Therefore, in 1964 a WHO Expert Committee was convened to reconsider the problem. The Committee concluded: "The target set by the Organization—namely that 80 percent of each segment of the population should be vaccinated—was found in practice to be unsatisfactory. . . . The target must be to cover 100 percent of the population" (10). And this indeed remained the strategy of the smallpox eradication program until 1967.

During the 12 years preceding my appointment as Director of WHO's Smallpox Program, I had worked at the Center for Disease Control under Dr. Alexander D. Langmuir—a period during which he had elaborated and developed a "Program for the Surveillance of Communicable Diseases of National Importance" (11). His inspiration was the renowned William Farr, for 40 years superintendent of the Statistical Department of the Registrar General's office. Langmuir summarized Farr's philosophy in these words: he had an "abiding faith that natural laws govern the occurrence of a disease, that these laws can be discovered by epidemiologic inquiry and that, when discovered, the causes of epidemics admit to a great extent of remedy." Langmuir pointed out in his 1962 Cutter Lecture that the CDC Surveillance Program represented an effort "to recapture some of the old and vital spirit of William Farr." He described the application at CDC of surveillance to malaria, poliomyelitis, influenza, and hepatitis and proposed its use for many other diseases. He defined surveillance as the "continued watchfulness over the distribution and trends of incidence through the systematic collection, consolidation and evaluation of morbidity and mortality reports and other relevant data. Intrinsic in the concept is the regular dissemination of the basic data and interpretations to all who have contributed and to all others who need to know." One does not spend 12 months, let alone 12 years, with Langmuir without obtaining a point of view. What was applicable to infectious diseases in the United States seemed logical to try to apply on an international scale in smallpox.

By July 1967, we had completed an operational manual for the smallpox eradication programs which stated (12):

The primary objective of the smallpox program is the eradication of this disease. Surveillance is thus an essential component of the program since the term 'eradication' implies that the number of cases of smallpox reach '0'. Surveillance represents a great deal more than case reporting alone. It is composed of several components:

- a) The routine, systematic collection of data, amplified appropriately by special field investigations and studies
- b) The concurrent analysis and interpretation of reported data and studies
- c) The initiation of appropriate definitive action including field investigation, epidemic control and modification of operational campaign procedures
- d) Widespread dissemination of the compiled and interpreted data to principal reporting sources and to others concerned with disease control activities.

Thus, from the beginning of the intensified smallpox program in 1967, emphasis was placed on the concomitant development of reporting and, more broadly, of a surveillance system in each country. At the same time, a systematic program of vaccination would be conducted which would be assessed independently by special teams.

Valuable information rapidly accrued. We soon discovered that, contrary to conventional wisdom, vaccination immunity was remarkably durable. In fact, to our surprise we learned that only a small percentage of those who had ever been vaccinated successfully, developed smallpox. The strategy changed to emphasize primary vaccination. An elaborate program in Afghanistan to vaccinate presumed susceptible women isolated in their homes in *purdah* was abandoned when epidemiologic investigation revealed that cases were almost entirely restricted to those under 15 years old. Women, by the time they entered *purdah*, had either experienced smallpox or they had been vaccinated. Many other changes were made.

However, the most significant of the findings emanating from surveillance activities came from Eastern Nigeria (13). In the first year of

the program, 1967, Dr. William H. Foege, now Director of the Center for Disease Control, demonstrated that an effective reporting system could be developed far more rapidly than we had believed possible and also that smallpox transmission could be interrupted rapidly by highly targeted, intensive containment vaccination—even when population immunity was less than 50 percent. Confirmation of his findings soon came from Brazil and Indonesia. The importance of more intensive surveillance-containment measures was clear. Translation of this into practice, however, proved far more difficult than we expected. National program authorities and indeed many of our own advisors, understood best and believed firmly in mass vaccination. Logistically, such programs are difficult to organize and execute, leaving little time for what many regarded as an activity of lesser, even peripheral interest which they little understood—surveillance-containment. Eventually, it became necessary to proclaim “surveillance-containment” as the single component of the program’s strategy, recognizing full well that whatever was said, vaccination programs would continue to be conducted. And, so they were, but surveillance began to receive substantially more attention. And steadily, smallpox vanished.

Paternity for the concept of smallpox eradication thus must be attributed to Soper, the father, and Gorgas, the grandfather. I hope, for the immediate future, the eradication lineage will expire there. Paternity for the surveillance strategy which led to smallpox eradication must be ascribed to Langmuir, the father, and Farr, the grandfather. May their offspring prosper because, I believe, the concept of surveillance is applicable and essential to disease control programs of all types throughout the world.

Comments

Epidemiology is intrinsic to surveillance, but also implicit in the development of surveillance systems are fundamental elements of sound management—of quality control, of designated and delegated responsibility and authority within an organizational structure, of responsiveness and an ability to change and to adapt to differing epidemiologic problems. Today’s international health religion calls for the delivery of primary health care, developed as “horizontal programs” to provide “health for all by the year 2000.”

I have no idea what “health for all by the year 2000” means, and I know of no one who expects to achieve it. “Primary health care” is a term which means all things to all people and is useless as an operational concept. So-called “vertical programs” are now regarded as passé. The key phrase today is “horizontal programs.” My own view of a “vertical” program is one for which clear objectives are decided, surveillance and assessment systems are developed to monitor progress, and, in brief, it is one in which a management structure is established. The “horizontal programs” that I have seen best describe the sleeping postures of the workers.

There are today infinite challenges and opportunities to improve health throughout the developing world, even within the limited resources now available. Regrettably, I feel, we are now working in a fog of slogans, of hazy ill-defined objectives, and of philosophy rather than of definitive programs.

Given direction, objectives, and leadership, there is no question in my mind that a wealth of human resources is prepared to respond. The potential is there for miraculous change in the health of people throughout the world within remarkably brief periods.

The success of the smallpox program can be replicated in other spheres of preventive medicine. More than this, as an editorial in the *Washington Post* in October 1979 stated: “The banding together of people everywhere, without regard to politics or national glory, to defeat a common enemy—is the true miracle.” The miracle can be replicated but only if we know where we are going.

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